MANGROVE DEVELOPMENT NORTH OF ADELAIDE, 1935-1982

by T. E. BURTON*

Summary

BURTON, T. E. (1982) Mangrove Development North of Adelaide, 1935–1982. *Trans. R. Soc. S. Aust.* **106**(4), 183-189, 30 November, 1982.

The mangrove coastline of the eastern shore of Gulf St Vincent exhibits three different patterns of mangrove development. In the northernmost area (which is free from human interference), the mangroves have been spreading seawards at approximately 18 m/year since 1949. In the area bounded by Port Gawler and St Kilda there has been little or no increase in mangrove development, while in the Swan Alley Creek area the mangrove stand has advanced inland at approximately 17 m/year since 1935. The unusual landward development of the mangrove stand in the latter area may be the result of a rise in sea level, a drop in land level or a combination of both.

KEY WORDS: *Avicennia marina*, mangrove, mudflat, progradation, sedimentation, salt marsh, samphire.

Introduction

The part of the eastern shoreline of Gulf St Vincent bounded by Swan Alley Creek in the south and Port Prime in the north, exhibits characteristics of a low wave energy environment. Extensive mudflats with mangrove vegetation occupy the intertidal zone of the shore and are in turn backed by salt marshes. For over 70% of the area, the landward boundary of the salt marshes, and in some areas of the mangroves, is determined by the placement of evaporation ponds by I.C.I. The effect of these ponds on the development of the mangrove areas is as yet uncertain.

The role attributed to mangroves is that of silt trappers, and in this respect, the grey mangrove *Avicennia marina* (Forst) Vierh. var. *resinifera* (Forst) Bakh., is more efficient at retaining sediment than (the prop-roots of) other mangrove species. McNae (1966) suggested that mangroves may play only a secondary role in causing accretion: mangroves consolidate silting rather than cause it. This view was reinforced by Bird (1972 p. 14) who stated that mangroves, after establishing themselves "shelter and stabilize the mud surface, reducing wave scour and retaining sediment that would be moved around on unvegetated mudflats".

McNae (1966) gave a brief description of some of the mangrove localities in Gulf St Vincent, and noted the relatively small height of the mature trees (3.5–5 m). Wester[1] gave an accurate description of the distribution of the mangrove in South Australia, while Kratochvil *et al.* (1972) drew a brief comparison of mangrove and salt marsh communities between several areas of southern Australia. Kucan[2] discussed man-made changes in the coastal zone north of Adelaide using historic aerial photographs; a comprehensive review of Australian mangroves and saltmarsh plants is offered by King (1981), while the most detailed work on South Australian mangroves is that of Butler *et al.* and Butler (1977).

The study area is located northwest of metropolitan Adelaide at 34°45′ south, 138°30′ east. The mangroves extend along the coastline for approximately 38 km and inland to a width of 2 km. The shoreline deposits consist of stranded beach ridges of sandy shell and swampy deposits which may extend up to 2 km inland, and which, in turn, are overlain in places by modern intertidal deposits. Eastwards are the alluvial Pooraka Clays formed prior to the beginning of the last major transgression (Firman 1967).

The bathymmetry of Gulf St Vincent is that of a shallow marine basin, the deepest areas being about 35 m. Mud banks extend up to

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[1] Wester, L. L. (1967) The Distribution of the mangrove in South Australia B.A. Thesis, University of Adelaide. Unpubl.

[2] Kucan, U. M. (1979) Man-made changes in the coastal zone between Port Adelaide and St Kilda. B.A. Thesis, Univ. Adelaide. Unpubl.

[3] Butler, A. J. Deepers, A. M., McKillup, S. C. & Thomas, D. P. (1975) The Conservation of Mangrove Swamps in South Australia. Report to the Nature Conservation Society of S. Aust. Unpubl.

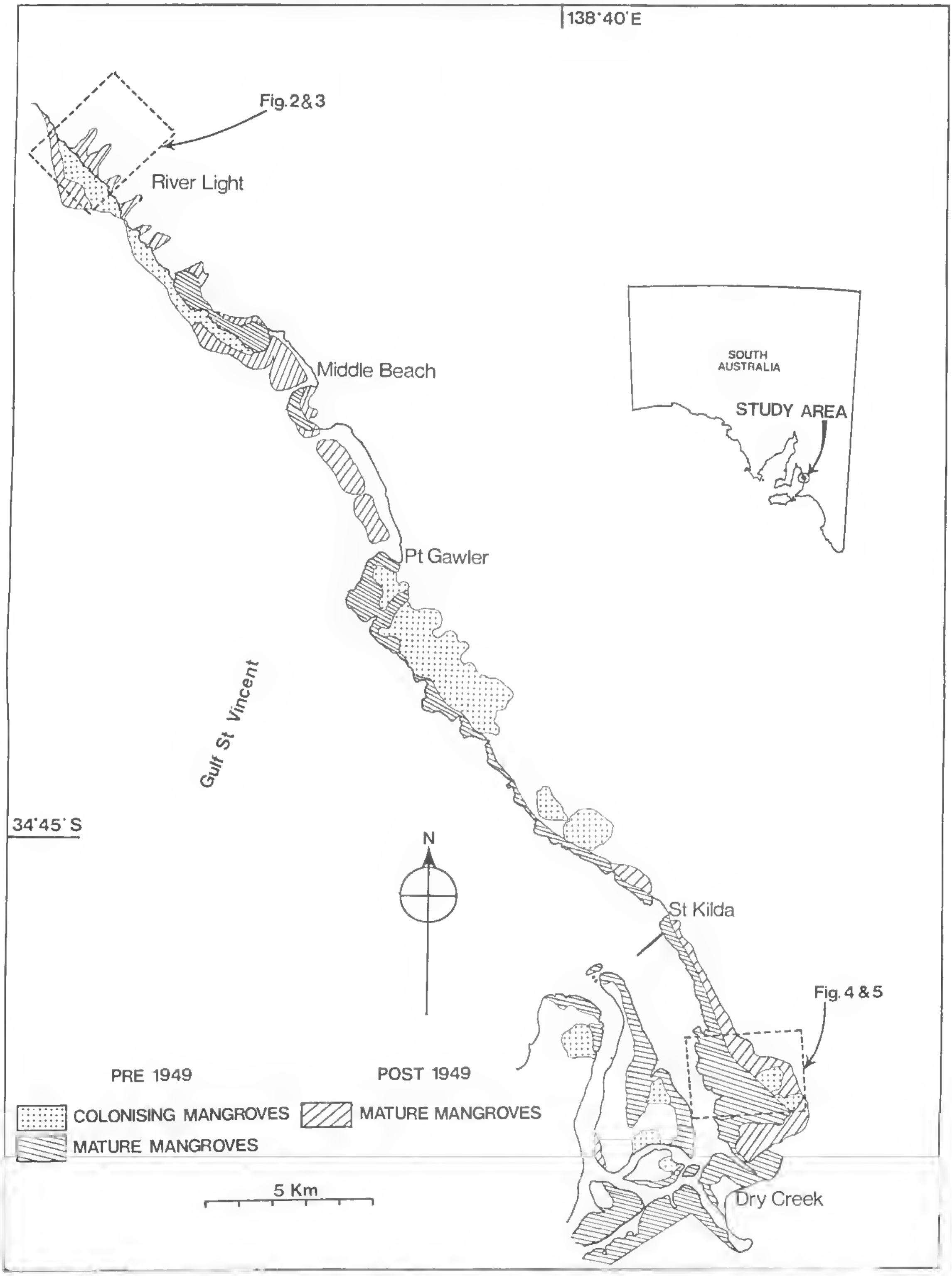

Fig. 1. Locality map showing mangrove development.

1 km offshore from the study area and are exposed at low tide. These mud banks generally are covered by marine meadows of the seagrass *Zostera muelleri* (Specht 1972) and to a lesser extent by *Heterozostera* sp.

The average air temperature for the area is 16°C with a summer average maximum of 27°C and a winter average maximum of 13°C. The average annual rainfall is 400 mm. The dominating wave action is the result of a southwesterly sea breeze.

The tides in the Gulf St Vincent region generally are semi-diurnal. An unusual situation exists in that the main semi-diurnal components (M_2 and S_2) are almost identical, which means that the semi-diurnal tide is virtually absent at neap tides—the diurnal tide being dominant. Near the equinoxes (about every 15 days) the diurnal components also vanish, resulting in an almost constant tidal level which remains for nearly a whole day. Such a condition is known as a dodge tide (Bye 1976).

Methods

Aerial photographs from 1949 to 1981 were obtained from the South Australian Department of Lands, whilst aerial photographs taken in 1935 were obtained from the RAAF in Melbourne. To compensate for different scales, equiscalar stereo observations were made using a stereo-zoom transfer scope. Mangrove areas were measured with a compensating planimeter.

Mangrove stands were deemed mature only if, when using aerial photographs, the canopy obscured the land features underneath. Ground inspection revealed these trees to be more than 2 m high.

Mangrove Development from Light River to Swan Alley Creek

The extent of mangrove development over the last 30 years is illustrated in Fig. 1. The area between Light River and Middle Beach has remained relatively undisturbed by human and industrial development. It is possible to trace the seaward advance of the mangrove stand across the pre-existing mud-flat of the Light River and adjacent areas using historic aerial photographs. Over a coastline of 11 km, 168 hectares of mature mangrove vegetation has increased to 356 hectares of mature and 134 hectares of immature mangrove. This suggests an increase of 10.7 hectares/annum.

At the shack settlement at Middle Beach are two areas of 26.2 and 11.1 hectares excavated for fertilizer extraction. These areas were cleared by front-end loaders.

Activities ceased prior to 1979 and, according to local reports, the excavated areas were completely cleared of mangroves. Present observations indicate an increase in mangrove numbers because seedlings are rooting on the exposed mudflats and sedimentation is also taking place.

South of the Middle Beach area in the late 1970's, I.C.I. built evaporation ponds whose seaward embankments protrude into the salt marsh areas and occasionally into the mangrove belt. This situation continues southeastwards as far as Swan Alley Creek and North Arm Creek. The ensuing effect on mangrove development is noticeably different from that in the River Light area. The seaward advance of the mangrove fringe has been negligible: approximately 0–3 hectares along a coastline of 34 km. The lack of seaward development of the mangroves may be due to a lack of sedimentation there. Study of the 1949 aerial photographs indicates sedimentation occurring at the creek mouths. Small distributary mouth shoals indicative of ordinary terrigenous sediment transport are present at each estuary. As the distributary mouth shoals are absent in the 1981 photographs, I assume that the placement of the evaporating ponds has halted or retarded terrigenous sediment supply to the coast.

The northern littoral movement of sand from the southern metropolitan coast could also have acted as a source of sediment supply. Culver[4] has suggested littoral sand movement rates in the order of 11,500–19,000 m^3/year. It is possible that some of the finer fraction may have been transported in suspension across Barker Inlet and deposited along the coastline between St Kilda and Pt Gawler — the coastline south of this area would receive little or no sediment as it is shielded by Torrens Island. Construction of the Outer Harbour breakwater and reclamation along the western shoreline of LeFevre Peninsula may have reduced the amount of suspended sediment reaching the mangrove areas. Culver[4] also states that survey figures for the Outer Harbour area suggest an accumulation

[4] Culver, R. (1970) Final Summary Report on Beach Erosion studies. Dept of Civil Engineering, University of Adelaide. Unpubl.

rate of sand and weed in the order of 26,800 m^3/year. This area may now be acting as a sink for sediment being transported northwards along the metropolitan coast. This would account for the still-stand condition of the mangrove front, assuming the view held by Bird (1972) that mangroves need a mud bank in order to establish themselves.

An inland advance of mangroves appears to have taken place between the Gawler River and Fresh Water Creek. Closer examination however reveals that the 1949 mangrove stand consisted mainly of immature trees, while in 1981 these trees have matured and so there is a larger area covered by canopy. This is not the case in the area of coast between St Kilda and Swan Alley Creek. Mangrove vegetation has increased inland at an approximate rate of 17 m/year, and all of the increase has been inside the embankment, which was construted in 1895. Little or no seaward advance has been detected over the past 45 years. This may be due to a retardation in terrigenous sediment input, assuming that mangrove stands will advance over a suitable seaward mud bank as appears to have been the case at Light River (see below).

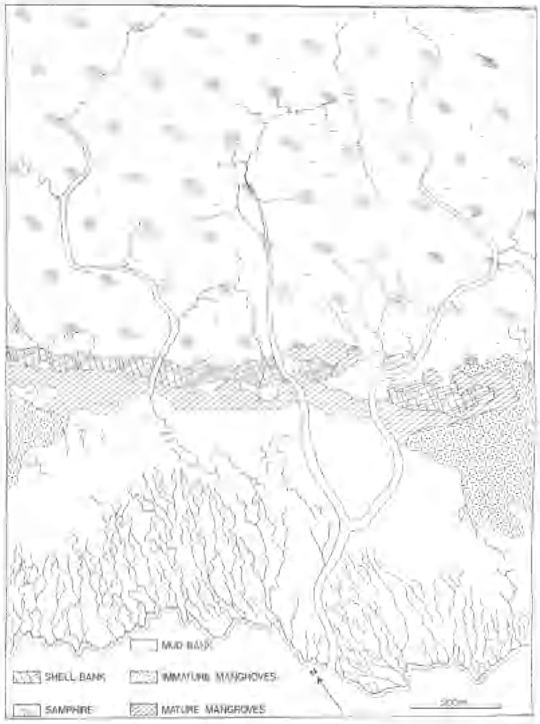

Fig. 2. Light River area (1949).

Progradation in the Light River area

Comparison of Figs 2 and 3 reveals two changes: the seaward spread of mature mangroves has increased at an average of approximately 18.2 m/year and the braided drainage pattern of a tide-dominated system across the mud pan has altered to the present system of fewer, larger channels. This has been confirmed by ground inspection. The landward spread of mangroves is less dramatic than the seaward spread and initially proceeds along the banks of tidal creeks and channels. This is because mangroves need to be flushed twice daily by the tide (Specht 1972). The presence of the pre-existing mud flat upon which the mangroves advanced therefore supports the opinions of Thom (1967) and Bird (1972), who considered that mangroves do not directly cause progradation; rather they consolidate it.

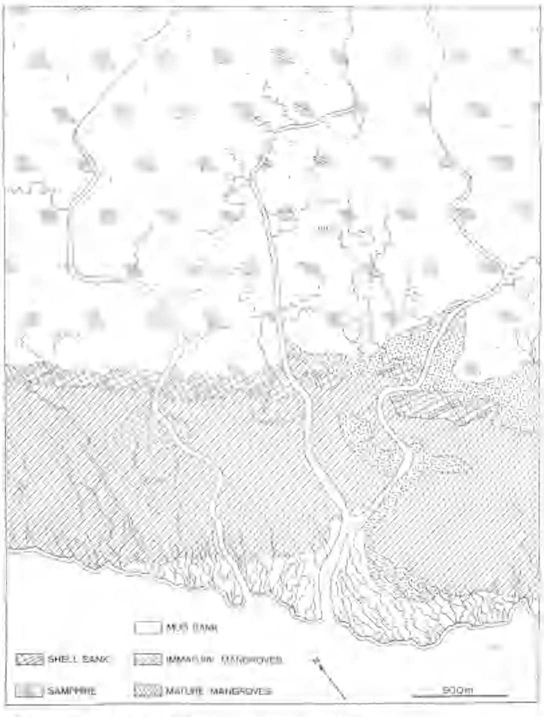

Fig. 3. Light River area (1982).

The Swan Alley Creek area

Aerial photographs taken by the RAAF in 1935 show this area to be relatively free from man-made interference—the only exception being an embankment (which was completed 40 years previously). Wester[1] stated that the embankment, built with the intention of reclaiming land behind it, had three outlet valves placed to allow outflow of accumulated water after flood tides. Examination of the 1894 plans from the Surveyor-General's office shows no such valves in the area. However, gaps in the embankment allowed the creeks to flow and allowed natural drainage to occur unimpeded. Mangroves within this area are able to survive as they are within the intertidal regime and continuous tidal flushing helps keep soil salinity down to a tolerable level.

From 1935 to 1981 the mangroves advanced inland at a rate of approximately 17m/year. Table 1 gives an indication of the landward increase in area of the mangrove stand. A study of various aerial photographs between 1935 and 1981 indicates that mangroves advance inland by firstly colonizing the banks and adjacent flood areas of the numerous tidal creeks.

Colonization continues until the intercreek areas are crowded with mature trees, and any continuing colonization occurs at a slower rate across the salt pan. There is little or no noticeable seaward spread of mangroves in this area (Figs 4 & 5).

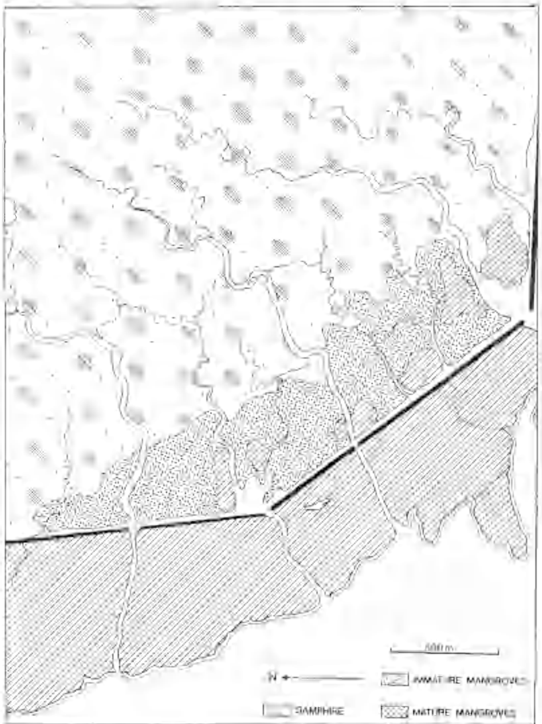

Fig. 4. Swan Alley Creek area (1936).

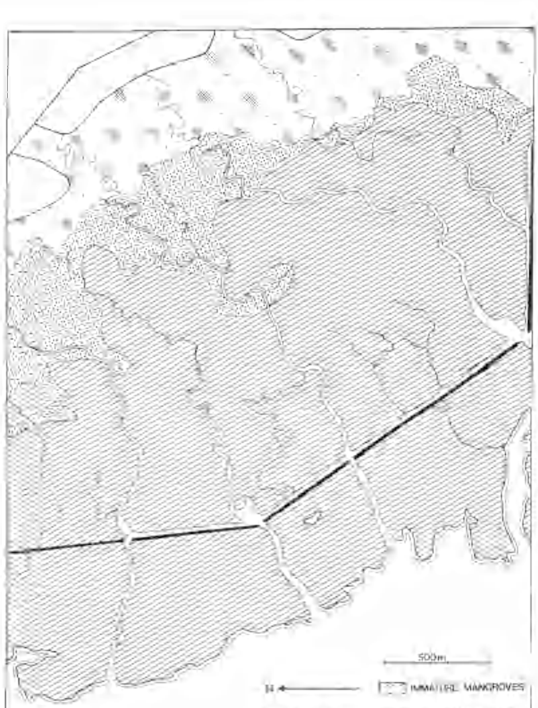

Fig. 5. Swan Alley Creek area (1982).

Discussion

The coastline between Light River and Swan Alley Creek can be considered to have three distinct areas of mangrove development: (i) the Light River area in which mangrove development is seaward across a pre-existing mud bank; (ii) the Pt Gawler-St Kilda area where the mangroves are stationary; and (iii) the Swan Alley Creek area where there is a rapid inland advance of mangroves.

The origin of the mud bank in the Light River area poses an interesting problem because mangrove progradation occurred only after 1949 (Fig. 2.). The mangrove stand at the time was mature and no progradation had as yet taken place. A possible explanation may

TABLE 1. *Increase in mangrove stands from 1949 to 1982.*

	Area of mature mangrove stands	
	River Light (Seaward increase)	Swan Alley (Landward increase)
1935	—	299 hectares
1949	168 hectares	456 hectares
1982	356 hectares	865 hectares

be due to a sudden change in sedimentation rate at the mouth of the Light River. This change in sedimentaion may owe its origin to the settlement and clearing of the North Adelaide plains. Smith[5] describes the settlement of the plains initially by pastoralists from around 1838 and thereafter by farmers on 80 acre blocks. He blamed the farmers for the destruction of the then existing natural ecosystem of scrub and extensive woodland. As a consequence, the surface water runoff was unchecked and unbound soil could be washed away during winter rainfall. Thus river sediment load would have increased and may have contributed to the mudbank at the Light River area. A contribution to the mudbank sediments could also have come from the extensive seagrass banks that lie seawards of the area. Davies (1970) indicated the significant role played by sea grasses in contributing calcareous material to shorelines. Analysis of the composition of sediments of the mud bank could confirm or negate the above hypothesis.

South of the Light River area (with the exception of parts of Gawler Beach), there is little or no mangrove progradation. Lack of terriginous sedimentation is probably due to the emplacement of evaporating ponds by I.C.I. along the shoreline, as well as man-made interference with the littoral drift northwards from the metropolitan beaches. This has resulted in the termination of water flow from numerous small rivers and creeks. The input of calcareous material from adjacent sea grasses should be similar to that in the Light River area, as there are extensive sea grass banks offshore; this, however, does not appear to be the case. The calcareous sediments from the seagrasses do not appear to be accumulating on the adjacent shore. This can be determined because (i) there is apparently no build up of an offshore mud bank and, (ii) the average pneumatophore length of the mangroves is similar to those of the Light River area. This implies that there is no excessive sedimentation in that area, as pneumatophore length (measured from the root) usually increases in the event of faster sedimentation (Chapman 1976).

In the Swan Alley Creek area the mangrove stand is advancing inland so that the area between the embankment and the evaporation ponds must now lie within the eulittoral zone (Macnae 1966). Examination of the construction drawings for the embankment reveals that the landward fringe of the mangrove stand in 1894 was located along the embankment site. With the landward advance of the mangrove stand, the implications are that there has been a rise in sea level, a drop in land level or a combination of both. Culver[4] believes the effective value of M.S.L. rise/century to be .274 m/c. This figure is a combination of a calculated land sinkage in the Semaphore-Pt Adelaide area of .183 m/c and an eustatic rise in M.S.L. of .091 m/c. A continuous rise in M.S.L. indicates that the advance of the mangroves will continue towards the evaporation pond boundaries.

[5] Smith, D. L. (1979) Land use and Groundwater History of the Northern Adelaide Plains. Report for the Engineering and Water Supply Department, Adelaide. Unpubl.

Acknowledgements

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References

Bird, E. C. F. (1972) Mangroves and Coastal Morphology in Cairns Bay, North Queensland. *J. Trop. Geog.* **35**, 11-16.

Butler, A. J. (1977) Distribution and Sediments of Mangrove Forests in South Australia. *Trans. R. Soc. S. Aust.*, **101**(1), 35-44.

Bye, J. A. T. (1976) Physical Oceanography of Gulf St Vincent and Investigator Strait. *In* C. R. Twidale, M. J. Tyler & B. P. Webb (Eds). "Natural History of the Adelaide Region". (Royal Society of South Australia Inc.: Adelaide).

Chapman, V. J. (1976) Mangrove vegetation. (Cramer: Los Angeles).

Davies, G. R. (1970) Carbonate Bank Sedimentation, Eastern Shark Bay, Western Australia. *In* Carbonate Sedimentation and Environment, Shark Bay, Western Australia. *Amer. Assoc. Petrol. Geologists. Mem* (13).

Firman, J. B. (1967) Stratigraphy of Late Cainozoic deposits in South Australia. *Trans. R. Soc. S. Aust.* **91**, 165-78.

King, R. J. (1981) Mangroves and saltmarsh plants. *In* Clayton, M. N. & King, R. J. (Eds) Marine Botany: an Australasian Perspective. (Longman Cheshire: Melbourne) pp. 308-28.

KRATOCHVIL, M., HANNON, N. G., CLARKE, L. D. (1972) Mangrove Swamp and Salt Marsh Communities in Southern Australia. *Proc. Linn. Soc. N.S.W.* **97**(4) 262-74.

MCNAE, W. (1966) Mangroves in Eastern and Southern Australia. *Aust. J. Bot.* **14**, 67-104.

SPECHT, R. L. (1972) The Vegetation of South Australia, (2nd Edtn) (Govt Printer: Adelaide).

THOM, B. G. (1967) Mangrove Ecology and Deltaic Geomorphology: Tabasco, Mexico. *J. Ecol.* **55**, 301-43.

STRATIGRAPHY OF THE CAMBRIAN-?EARLY ORDOVICAN, MOUNT JOHNS RANGE, NE OFFICER BASIN, SOUTH AUSTRALIA

BY M. C. BENBOW

Summary

A revision of the Cambrian to?Early Ordovician stratigraphy of the northeastern Officer Basin, South Australia, has been based on mapping of the Mount Johns Range.